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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a two-part unit focusing on chemical concepts and basic laboratory skills. The ideas that matter is composed of small particles and that chemical energy is involved when these particles react are stressed throughout the unit. The first part of the unit teaches about the breaking down of substances into smaller pieces, leading to the concept of a "smallest possible" particle. The second part leads to the definition of a chemical reaction, bringing in the idea of elements and compounds. Each section in this guide corresponds to a given section in the student study guide. (JN)

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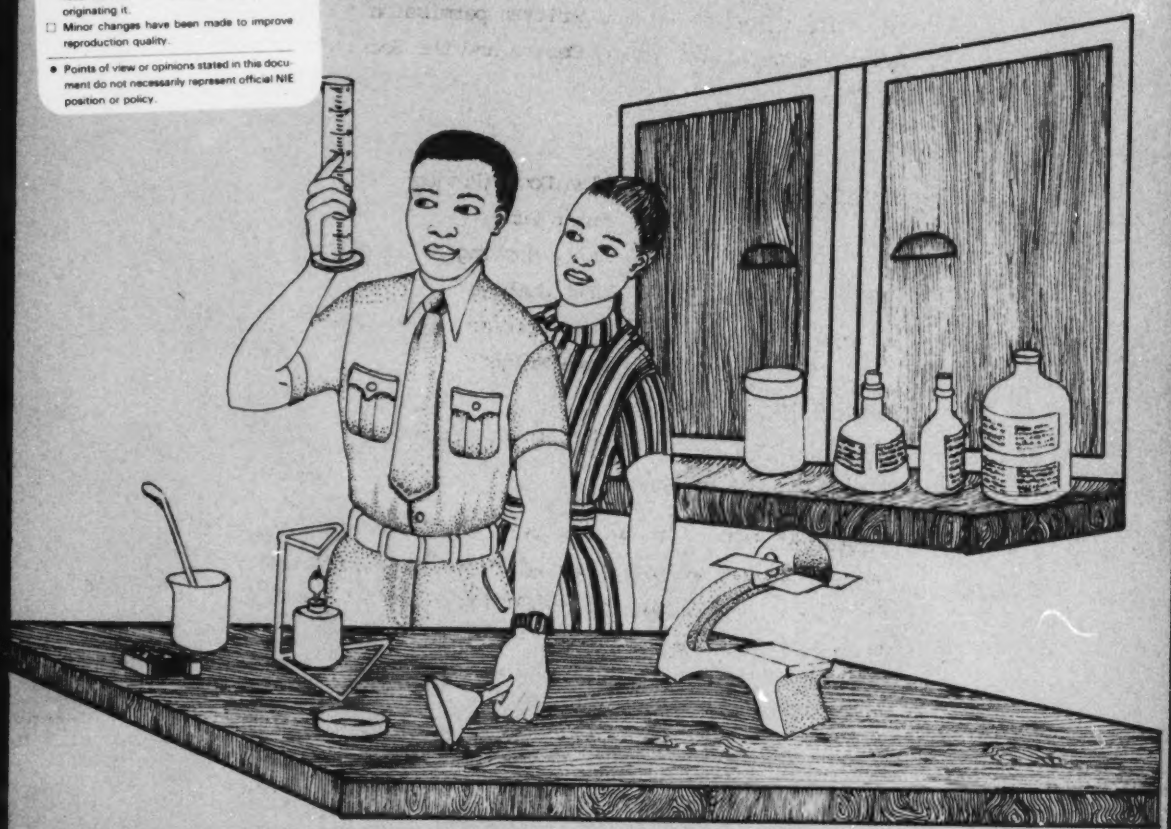

TEACHER'S GUIDE UNIT C1

What is matter?

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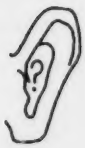
FEBRUARY, 1981

TEACHER'S GUIDE

In the guide to each lesson, symbols will be used to indicate the point at which teacher activity might be needed. The symbols are as follows:

Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.

Written exercises for the pupils. If possible these should be put on the black-board before practical work begins so that the pupils can see what to look for.



Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol. These will appear at the same points in the study guide.

Take note of an important point.

TEACHERS GUIDE

Unit C 1 - What is matter?

This unit is a chemistry unit involving the presentation of simple concepts and some basic skills. The ideas that matter is composed of small particles and that chemical energy is involved when these particles react are fundamental to the understanding of chemistry and are stressed throughout the lesson.

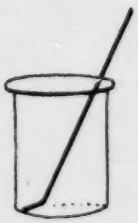
The first part of the lesson teaches about breaking up substances into smaller pieces, leading to the idea of a "smallest possible" particle.

The second part leads to the definition of a chemical reaction bringing in the idea of elements and compounds.

Lastly, some practical skills are taught in the experiments which are done by the pupils.

Part 1 page 2 Please ensure that all pupils have the apparatus ready, including the "clean dry stone". Encourage clean, orderly work with as much space as possible around the pupils.

The following quantities are recommended for the chemicals mentioned on page 2.



1. Copper wire: 5 cm per pair of pupils.
   This should be cut up before the lesson and placed in an evaporating dish on your table. One pupil from each pair can then come up to your desk to collect the wire. When he has collected it he can go to the seeds.
2. Seeds: a small handful per pair of pupils.
   As soon as the first pupil has the wire, he can collect a handful of seeds from a dish also on your desk. He should put the seeds in his tall cup.
3. Dyestuff: (potassium permanganate) 1/4 spatula full per pair, that is a very small quantity. The second member of the pair should bring up the evaporating dish from the pupils basic kit to collect the small quantity of dyestuff.

The ideas to be presented in this section are outlined below. One possible way that the lesson may be taught is also given, but need not be followed if you prefer a more personal approach. Please do as you wish!

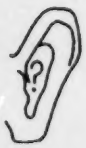
Recommended teacher activity to accompany pages 3 - 7

1. Page 3. Introduce this part of the lesson by telling the pupil what to do with the copper wire.

The main idea: You should ask them to break up the wire into smaller and smaller pieces, until the idea of a "smallest possible particle" is reached. What follows is one way in which you might get this idea over to the pupils. We suggest you read this to the pupils as it will save you time. When you feel you have more experience of the course you may like to express the main idea in your own words.

> "Have a look at the copper wire. Perhaps you have seen copper before, either as wire, or as some useful article. Look at the wire carefully. It is very smooth and shiny, isn't it? You will be able to pull it gently between your fingers and make it almost straight. Now break the wire into two pieces. You may have to twist a bit and pull sharply to get the wire to break. Put one piece down, and try to break the other into two again. Now go on breaking the wire into smaller and smaller pieces.
>
> It gets harder and harder to catch hold of the little bits, doesn't it? If we had a sharp knife, perhaps we could cut the little pieces up and get some smaller ones, but even then we would find that the pieces would become too small to cut".

Please look at the study guide for the next set of instructions.



2. Page 3. Some ideas to give the pupils on making particles smaller

Main ideas: That water is able to pull particles apart more effectively than grinding up, etc. The way to make a solution.

As before, when you introduced the copper wire you might like to read:

"Did you think of using your stone? Try now to grind up the pieces. Have a look at what you have done. There are so many pieces that you couldn't possibly count them, could you? Do you think that you have NOW made the smallest possible particle? I'm sure you don't think so, because you can still see the pieces of dyestuff very easily and you will see that some are bigger than others. If we had a better grindstone, we could get them to a smaller size, but how small could we go down to in the end? Is there a particle that cannot possibly be made smaller?

We can see that the pieces of dyestuff are a reddish blue colour. It might be easier to see them if we put a little bit into water. Take your graduated beaker and put water into it almost to the top. You will see some marks on the side indicating from 5 ml to 50 ml. Try to get the water level with the 50 ml mark. Put the beaker down. Hold the tin above the beaker - don't tip it yet! Now, using the stirring rod as a scraper, try to scrape one or two little bits from the tin into the beaker. Just one or two will do - be very careful not to scrape a lot!

I expect two or three went in - that's fine. Look at them as they fall through the water. They are making little lines in the water, aren't they? Well, if each little particle is reddish blue, there must have been quite a few particles to make each little line.

It seems that the water is spreading out each little piece of dyestuff into many smaller particles. We can see them because they are strongly coloured.

Now give the liquid a stir with the stirring rod. You will see that the little lines go away and that the water becomes a reddish colour from the top to the bottom. We have a chemical name for this : we say that you have made a SOLUTION of dyestuff in water".

Return to the study guide now for further pupil activity.

3. Page 4. Introduce the seeds ás soon as the pupils have turned to Diagram 1. Note there is an error in the script as they do not have a "packet" - the seeds are in their tall cup.

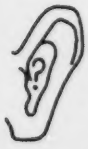
The main idea.

The seeds and beaker picture is a useful model of particle behaviour. It will be mentioned again later in the text. By using seeds the pupils acquire an understanding of how particles behave.

As before, when you gave instructions about the dye-stuff, you might like to read:

"Put all the seeds into the palm of your hand. We shall pretend that this pile of seeds is one of the pieces of dyestuff that you put into the water. Diagram 1 is a large picture of the graduated beaker you are using. Put the seeds in a pile in the middle of the beaker in the picture. Now pull the seeds apart little by little until the seeds are more spread out. This is what the water did to the pieces of dyestuff : it gradually pulled off small pieces which then spread out through the water. Your stirring helped this to happen: after you had stirred, the little particles were spread very evenly through the water. Spread out your seeds until they are evenly placed over the whole picture of the beaker. This is what a solution really is - many particles spread through the liquid just as your seeds are - only the particles of dyestuff are so small that we cannot see each separate one."

Please return to the study guide now for the explanation of a "model".



4. Page 4. The dyestuff dilution model

Main idea

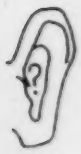
Most of the seeds can be taken away and the rest spread out over the picture. The idea of dilution is then illustrated.

As before, when you described the first use of the model, you might like to read:

"Find the 5 ml mark on the diagram of the beaker near the bottom of the page. Have you found it? The 5 ml mark? Good. Now take away all the seeds above the 5 ml mark. Put them on one side out of the way. Leave the few seeds below the mark - the ones near the bottom of the beaker.

Now most of the beaker is empty and there are a few seeds at the bottom. You have taken away about nine tenths of the particles and you have one tenth left. Now spread out these few seeds right across the picture so that they are evenly placed all over the beaker from the top to the bottom. There are now much fewer particles in the whole space, aren't there? You have spread out one tenth of the number of seeds into the same big space that you started with. If we now remove nine tenths again, we shall probably have only one or two below the 5 ml mark. Try that now.

When we spread these out, we realise that the solution has now lost most of the particles we put in."



For a summary of this, return now to the study guide.

5. Page 7. The dilution of dyestuff

It would be useful to write Exercise 1 on the board BEFORE the pupils commence this experiment so that they can see what is expected of them.
Please guide the pupils carefully through this experiment. The following points are important and should be stressed to the pupils.

a) The solution should be well stirred every time the dilution is done, so that the particles of dyestuff are distributed evenly in the water from the top to the bottom. This is called a UNIFORM SOLUTION.

b) The pupils can see the colour getting less and less if they hold the beaker up to their eyes, and look at the light through the solution.

c) The pupils should pour away the unwanted liquid into a waste tin.

d) When the first dilution is complete, the pupils should realise that they have left only one tenth of the particles they started with. This small amount is spread out in the water, just as they did with the seeds. At the end, after many dilutions, very few particles are left.

e) If the solutions are all well stirred each time it should take about ten or twelve dilutions before the colour cannot be seen any more.

Exercise 1 (To be written on the blackboard)
Copy this chart and fill it in as you work through the experiment. (Note to the teacher: the chart has been started for you so that you can see how the pupils should fill it in.)

REMEMBER TO STIR WELL EACH TIME

	Colour visible	Number of particles left
1st dilution (10 times weaker now)	✓ (yes)	10 times fewer than before
2nd dilution (10 times weaker again)	✓	10 times fewer again
3rd dilution		
	Continue by yourself	

Now answer the questions on the next page.)

7.

1. How many times in all did you dilute the solution before the colour could not be seen?
   ..... times.
2. By looking at the number of times you diluted the solution, what do you think about the number of particles you had? Were there few, or many?
   .....
3. What does this number of particles tell you about the real SIZE of the particles?
   .....
   .....
   .....
   .....

This exercise puts into the pupil notes the results they obtain and the conclusion needed for the Practical work on P. 7. of the study guide.

Exercise 2.

(This exercise must be done by the pupils after they have completed Exercise 1.)
FILL IN THE BLANK SPACES YOURSELF

Summary: What we have learned.

1. We can break up dyestuff by using _____ to pull the particles apart.
2. The _____ spread through the water to make a solution.
3. There are _____ particles in each little piece of dyestuff.
4. The particles of dyestuff are very _____ in size.
5. A uniform mixture of two substances is called a s_____
6. Making weaker by adding water is called d_____

Answers (for the teacher)

1. Water
2. Particles
3. many
4. small
5. solution
6. dilution

Note This takes you to page 8.

Page 8. To observe Copper Sulphate in water

Please issue 1/2 spatula copper sulphate per pair of pupils. They should put it into their clean evaporating dish.

The pupils should observe the spreading blue colour moving away into the water. This may take some time. They should keep the solution, as instructed. The pupils can then answer Exercise 3 from the blackboard.

Exercise 3

Copper sulphate Solution

1. What did you observe happening to the piece of copper sulphate?

   .....

   .....

2. What do you think the water was doing to the piece of copper sulphate?

   .....

   .....

3. In the blue solution could you see any particles of copper sulphate?

   .....

4. What does this tell you about the size of the copper sulphate particles?

   .....

Page 9. Please have the bottle of sulphur ready, to show the pupils what it looks like.

9.

To show that copper is one of the chemicals in copper sulphate

This experiment should clearly show the copper coming out onto the nail, especially if you leave it overnight. However, pupils sometimes conclude that the red colour is "rust". You could point out that the second nail is not "rusty" and ask them to read the title of the experiment again before doing Exercise 4 from the blackboard.

Exercise 4: Iron/copper sulphate experiment

1. What did you observe in this experiment?

.....

.....

.....

2. What do you think the substance on the nail might be?

.....

Page 10. If the ammonium dichromate is slightly damp, it may take a little while to get going. A few matches may be needed, but once it goes properly the match should be removed. Please encourage the pupils to feel underneath the dish as the heat of reaction is considerable.

In the discussion following this experiment the pupils may be referred back to their previous lesson on energy and this should help them to understand.

They can then attempt Exercise 5.

Exercise 5

Ammonium dichromate reaction

1. What colour was the reactant? .....
2. What colour was the product? .....
3. How did you make the reaction begin?

.....

.....

4. What happened when you took away the lighted match?

.....

.....

5. What does this tell you about the reaction?

.....

.....

.....

6. Complete the following statement:
Orange reactant and a little heat changes to
..... product and
a lot of .....

Page 11. Iron and sulphur experiment

Quantities required per pair of pupils:

3 spatulas iron filings (into their tall cup)
3 spatulas sulphur (into their graduated beaker)
2 pieces aluminium foil about 10 cm square

2 spatulas of each are used in this experiment and 1 spatula of each should be kept for later.

Please make sure that the pupils heat the two "parcels" evenly in the middle of the dish. The "parcels" will be too hot to hold for a minute or so, but as soon as possible the pupils should pick them up to feel the heat of reaction.

If they find iron or sulphur left over, you could lead them into deciding that the extra did not react because there was a little bit too much of it there. This encourages the idea that chemicals react in fixed amounts, and that any excess just remains unreacted.

Exercise 6

Iron sulphur experiment

1. What was the appearance of the mixture before the experiment began? .....
.....

2. What did you find at the end?
.....
.....

3. Do you think that a chemical reaction took place?
.....

4. Explain your reasons. .....
.....

Pages 13 and 14. The definitions should be copied into exercise books and learned well by the pupils. They can try the "How much do you know" exercise once they have learned the definitions.

Part 2

Page 15. To study a mixture and a compound

The pupils will need their hand lenses and magnets for this experiment. Water will also be needed. Exercise 7 should be answered as they work through the experiment.

Exercise 7

Mixtures and compounds

1. What did you observe when you rubbed the magnet in the mixture?

   .....
   .....
   .....

2. Do you think that this was a good method of separating iron and sulphur? Why do you think so?

   .....
   .....
   .....

3. What did you observe when you held the magnet next to the compound?

   .....
   .....
   .....
   .....

4. What did you observe when the iron sulphide was put into water?

   .....
   .....
   .....

Page 16. A mixture of sand and water

Quantify of sand required: 1 spatula full per pair of pupils.

The pupils should put their sand in their graduated beaker.

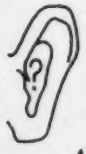
Water will be required for this experiment.

Page 17. A mixture of sodium chloride and water

Q uantity of sodium chloride required: 1 spatula full per pair of pupils.

The pupils should put the sodium chloride into their evaporating dish. It should be VERY CLEAN INDEED.

Water will be required for this experiment. They should keep the solution (as instructed) In the discussion following this experiment, the pupils are told that they MAY taste the solution. It is quite safe to taste it.



Page 18. Model of beaker.

It would be very helpful if you read out the instructions opposite the diagram in the study guide.

Page 20 Heating sodium chloride

The solution from the previous experiment should be used here. Please put Exercise 8 on the blackboard before they begin so that they know what to look for.

Exercise 8

Evaporation

1. What was left in the tin after all the water was lost as steam?

   .....

2. Describe briefly what you observed towards the end of the experiment when almost all the water had gone. Try to mention everything you noticed.

   .....

   .....

   .....

   .....

Page 21. Filtration

Quantities required: 1 piece filter paper per pair of pupils. The solution is the same one that they prepared earlier. They can answer Exercise 9 from the blackboard as soon as they have finished.

Exercise 9

Filtration

1. After filtering, what remained on the paper?
   .....
2. After filtering, what had passed through the paper? .....
3. This was because:
   (a) Grains of sand are larger than holes in filter paper?

   OR

   (b) Particles of water are larger than holes in filter paper?

Note: The following exercise is supplementary and is not mentioned in the study guide. If you are pressed for time, you need not ask the class to do the exercise. Perhaps you could just tell them about it. However if they have time, it is a valuable addition.

You will have to make up a mixture of sand and salt in about half : half quantities.

Supplementary exercise : Mixture of salt and sand

Give each pair of students 2 spatulas of the mixture. Tell them that this mixture was made by accident when a sample of sand fell into some salt and that you would like them to separate the sand and the salt for you and give back the two parts of the mixture so that you can use them. When they start to separate them, remind them that: (i) sand does NOT dissolve in water

(ii) they can get back dissolved substances by evaporation.

Page 22. Definitions

These should be copied into their exercise books.

Page 23. Table 1

This should be copied into their exercise books.

Pages 23 - 25 Growing sodium chloride crystals

1. Page 23 Quantities required per pair: A small handful of seeds as before.

Main Idea

The pupils are led to the idea of closely packed particles by further use of the seed model.

You might like to read the text below as you did before.

"To finish off this lesson, turn once again to your picture of the beaker in Diagram 1. Find the bean seeds again and spread them out as before all over the picture.

Now pretend that the water is going away. Push the seeds together, making sure that they do not go into a pile but remain flat on the paper. Get them as close together as you possibly can. You will see that there are not too many spaces between the seeds - they can get quite close even though they are a lumpy sort of shape. When particles are allowed to come together slowly, they get close together too, and this is called CLOSE PACKING.

Remember your evaporating experiments? You took all the water away, but you did it quite quickly so the particles of sodium chloride never had a chance to join up into very big pieces. The sodium chloride was spread all over the tin in a rather powdery form. We shall try in a minute to make a much more beautiful form of sodium chloride by allowing the particles to come together very slowly.

Pick up the seeds now and turn back to page 23 in your study guide".

Return to page 23 for a summary.

2. page 24

What to tell the pupils about the sodium chloride

Quantities required per pair: The tall cup half full of sodium chloride. A string and weight (10 cm string per pair is enough) Pupils should find a short thin stick from the garden.

Main idea

The sodium chloride particles will grow on the string and on the top of the extra salt. They will be cubic in shape.

You might like to read the final text below.

"Let us set up our experiment now.
We shall make a very strong solution of sodium chloride and allow it to stand for many days. As the water evaporates into the air, the particles will come together to make big pieces. It will help the pieces to grow bigger if we give them something to fasten on to.

First, find the TALL CUP half full of sodium chloride. I really do mean half full - you need a lot for this experiment. Add water almost to the very top and stir very well. When you stop stirring, you will find that the extra sodium chloride which has not dissolved will settle to the bottom of the cup. The solution of sodium chloride now holds as much salt as it possibly can. Stop stirring now.

Tie the string around the stick as shown in Diagram 1 and hang the string so that the weight rests just on top of the salt as shown in the diagram. If the string is too long, wind it round until it is exactly the right length.

Leave the whole thing for a week in a cool place where it cannot be disturbed. You will see the pieces of sodium chloride growing on the string as the days go by, and I shall ask you some questions about the experiment next lesson".

Note: Do not leave the tall cups in the sun. The water will evaporate too quickly and a nasty crust will form on the surface of the liquid. A cool place is very important.

Page 25. Summary Unit C 1

The pupils could copy this into their exercise books.

N.B.

If you have any comments on this unit, please write and let us know what they are. We look forward to hearing from you. We hope you enjoyed teaching this lesson.

Zim - Sci Team

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